The CRUSHED STONE JOURNAL

PUBLISHED QUARTERLY

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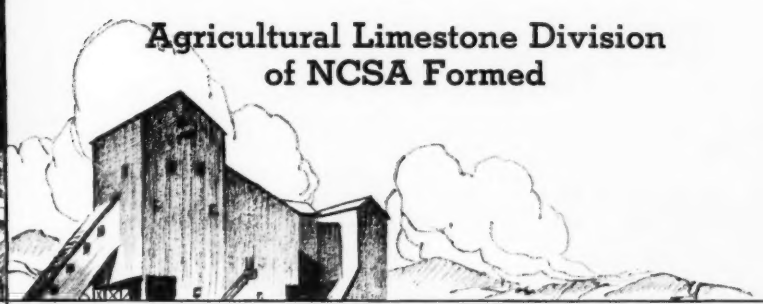
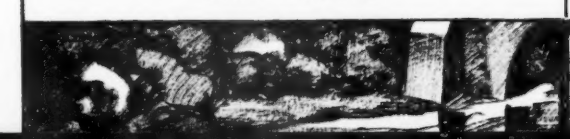


June · 1945

Official Publication
NATIONAL CRUSHED STONE ASSOCIATION



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The Crushed Stone Journal

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J. R. BOYD, Editor

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NATIONAL CRUSHED STONE ASSOCIATION · 1918 ·

THE CRUSHED STONE JOURNAL

WASHINGTON, D. C.

Vol. XX No. 2 PUBLISHED QUARTERLY JUNE, 1945

Some Effects of Air-Entrainment and Coarse Aggregate Type on the Properties of Concrete[1]

By CHARLES E. WUERPEL

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Mount Vernon, N. Y.

• **Every so often a new idea comes to light which results in very considerable benefit. That has occurred in the Portland cement concrete industry. It has been found that the introduction of minute quantities of materials which will act to entrain a small volume of microscopic bubbles in concrete will greatly improve its resistance to freezing and thawing. The present article by an outstanding authority discusses this subject in a very interesting way.**

I WAS particularly pleased to be invited to address you because I have had the feeling that the cement industry has been far more active in their interest in availing themselves of the facilities of our laboratory than has the aggregate industry. We are a public institution, conducted by the Corps of Engineers of the U. S. Army, and our function is a dual one. Unfortunately, I am afraid that you know our laboratory best in only one of its phases, that of accepting, or rejecting your product. The second phase is research and development.

I consider the "acceptance" phase to be definitely the lesser in importance of our two missions, and I have been impressed by the fact that when a material is submitted to us for acceptance or rejection, it is a rather cut and dried affair. Either the material meets the project specification and is used, or it does not meet the specification and is not used. I do not know just where the fault lies, but that is not quite the attitude that has developed between ourselves and the cement industry. We work together and try to avoid rejections by making the cement acceptable, and I would like to invite you at this time to make such use of the laboratory. I get no pride, no joy at all, out of rejecting anyone's material; whether it be crushed stone, gravel, sand, cement, or membranes for curing concrete.

I think, too, if I may be permitted to criticize (and if I do, it is in the best possible spirit), that you have not taken advantage adequately of what your very brilliant speaker, Colonel Chevalier, stressed last night, that progress in this world in the postwar period is going to depend very largely on science and technology. Well, science and technology have to be fed as well as the laborer and the management of which Colonel Chevalier spoke, too. It costs money, and I think that I can cite the fact that the cement industry has recognized this and spends an incomparably greater amount of money on development and research than does the aggregate industry—and I use that term collectively and not solely to apply to your Association.

You have an eminent Director of Engineering. It

[1] Presented at the 28th Annual Convention, National Crushed Stone Association, Hotel New Yorker, New York City, January 29-31, 1945.

is not my place to state what his facilities should be, but I think that you have depended too much on others to obtain information which you need for the development of your product to the point where there will be a more apt use of your product, a more general use, and a more satisfactory use.

I was invited to speak to you on the subject of concrete durability. Obviously, that is a very, very broad subject which I could not conceivably cover in any reasonable period of time, but since today the subject of air-entrainment forms the focus of thoughts of durability, I will make the basis of this address a series of tests that we ran during 1943 and 1944, some of which are still incompleted, in which we tried to determine means of improving the usability of Vinsol resin with cement to improve the durability of concrete.

We have tried to keep our attitude toward air-entrainment definitely in the fluid stage. We became convinced in 1939 and in 1940 that the use of Vinsol resin in cement offered promise of being the greatest improvement in the technology of concrete that has come into use since Portland cement was first made. We have used a great deal of such cement. We have used over 2,000,000 barrels of it in some 168 projects. We did not get uniformly excellent results. Had we expected it, we would have been very rash. We knew it was a new material and that we would have to learn how to use it, and in at least 95 per cent of the cases, we did benefit tremendously by its use. However, our constant effort has been to improve means by which it could be used, so the program which I will get into very shortly now dealt with the use of cement treated with the original so-called flake Vinsol resin; and then, too, with the cement treated with a neutralized Vinsol resin. If you will bear with me for a moment, I would like to indicate to you the fundamental difference between the two.

When Vinsol resin was first interground with cement, it was added as the resin, nothing more than that. It depended upon being neutralized and made into a metallic soap by reaction with the readily soluble alkalies which go into solution when water is added to the cement. Prior to the time the cement was added to the mixer, the material was simply an inactive resin. It had done nothing to the cement. But in the very brief period in which it was in the mixer with the cement and with the water, the resin was neutralized into a metallic soap which had the sudsing properties which brought about the entrainment of the air. However, that was depending too much on a gamble as to how much of this soluble alkali would be dissolved in the brief period during which the concrete was in the mixer. Also, there were certain inhibitors and catalysts present which made the results rather unpredictable. So we worked on the problem of adding the Vinsol resin to the cement in a pre-neutralized condition by making it a sodium resinate.

The program that we have here was made possible by the cooperation of four cement companies[2] who agreed at some considerable cost to themselves to manufacture on a commercial scale rather large quantities of cement, the first portion of which was a plain cement meeting A.S.T.M. C-150 Type 2 or Federal SS-C-206a specification. Then they added flake Vinsol resin (0.03 per cent) and continued the run. Then they discontinued the flake Vinsol resin and added .01 per cent of the neutralized Vinsol resin. After having run that, they started adding .03 per cent of neutralized Vinsol resin. The four lots of cement from each of the five mills were bagged and sent to the laboratory. We had over 200 bags of cement at the laboratory for the work.

I am not going to try to stress the particular phase of this work which dealt with Vinsol resin as such, because also introduced into the program were two types of aggregate. Up to that time we had used the Long Island gravel as our standard aggregate for research tests. Due to the very diplomatic and agreeably persistent efforts of one of your members, we were induced to include a crushed stone in this particular program on a par with the gravel. Heretofore, too, we have followed the policy of adopting a given water-cement ratio and letting the cement factor be what it might be as a function of the coefficient of friction of the aggregate; what we call the "cement demand." In this particular case, we decided to keep the cement content constant and let the water-cement ratio be determined by the coefficient of friction of the aggregate, which is something of a departure, and it is the effect of the aggregate on the properties of the concrete made under these conditions which I will stress in this address, although you will see the effects, too, of the various types of Vinsol resin.

I know that slides, especially slides of tables, are not too agreeable to an audience. They are hard to follow, but it is necessary in this talk to rely principally on fifteen slides and I hope that you will bear with me.

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[2] Lone Star Cement Co., Hudson, N. Y. plant.
Universal Atlas Cement Co., Hudson, N. Y. plant.
Glens Falls Cement Co., Glens Falls, N. Y. plant.
Penn-Dixie Cement Corp., Bath, Pa., plant.
Penn-Dixie Cement Corp., Nazareth, Pa. plant.

FIGURE 1

CR-NVR Program
Influence of Vinsol Resin (Type and Amount) on Properties of Concrete

Coarse Aggregate	Cement	Water-Cement Ratio, gal. per sack				Actual Cement Factor [1] sacks per cu. yd.				Sand-Aggregate Ratio—%			
		Plain	V. R.	0.01% NVR	0.02% NVR	Plain	V. R.	0.01% NVR	0.02% NVR	Plain	V. R.	0.01% NVR	0.02% NVR
Gravel	A	6.0	5.60	5.60	5.44	5.38	5.23	5.27	5.13	38	33	33	33
"	B	6.0	5.50	5.60	5.52	5.35	5.18	5.25	5.16	38	33	33	33
"	C	6.0	5.35	5.47	5.27	5.32	4.95	5.21	5.11	38	33	33	33
"	D	6.20	5.75	5.70	5.45	5.37	5.22	5.20	5.07	38	33	33	33
"	E	6.20	5.70	5.67	5.42	5.33	5.17	5.20	5.10	38	33	33	33
Stone	A	7.10	6.55	6.48	6.17	5.30	5.13	5.18	5.05a	44.5	37.5	37.5	36.5
"	B	7.10	6.45	6.52	6.23	5.37	5.20	5.19a	5.08	44.5	37.5	37.5	36.5
"	C	7.10	6.0	5.97	5.80	5.23	4.78	5.15	5.01	44.5	37.5	37.5	36.5
"	D	7.25	6.60	6.40	6.00	5.30	5.20	5.20	4.97	44.5	37.5	36.5	36.5
"	E	7.25	6.50	6.37	6.10	5.29	5.12	5.12	5.00	44.5	37.5	36.5	36.5
Average of all Gravel Mixes		6.08	5.58	5.61	5.42	5.35	5.15	5.22	5.11	38	33	33	33
Average of all Stone Mixes		7.16	6.43	6.35	6.06	5.30	5.09	5.17	5.02	44.5	37.5	37.1	36.5

[1] The basic "actual" cement factor for the entire program was determined on mixtures of the four 206a cements using gravel aggregate and was found to be 5.37 sacks/cu. yd.

Note: All individual values shown in the body of the table are averages of three results, except the two marked "a", which are averages of four results.

Before we get into the slides, I would like to have you know what the fundamentals of the program were. The so-called fixed factor of the cement content for the program was determined on the basis of mixture designs with a blend of four of the untreated cements. It turned out to be 5.37 bags per cubic yard. You might keep that in mind. It is roughly comparable to a 5½-bag mix with which you are familiar. The water-cement ratio was entirely variable, depending upon the demand of the cement, the presence or absence of the air-entraining agent, or the relative coefficients of friction of the round gravel and the angular crushed stone. The slump was maintained, basically, at 2½ inches. That, too, varied slightly within the program because, as I have said, the design was based on an initial mix with the blend of cements, but basically it was a 2½ inch slump; which is a very general slump today. We would like to see it more general.

The sand-aggregate ratio was variable as required not only by the aggregate that was used, but also by the air-entraining agent used. The sand was the typical North Shore Long Island siliceous sand with a finess modulus of approximately 2.7. The gravel was the Long Island uncrushed gravel with a ¾ inch maximum size and the stone was a recrushed (and mark that, please) trap rock produced by the New Haven Trap Rock Company with a ¾ inch maximum size. I should like to stress the fact that it was recrushed and that the shape was highly cubical and was not characterized by the flat and slivery shape which is all too frequently encountered in crushed stone.

Characteristics of Plastic Concrete

I will not attempt to discuss the individual values shown in Figure 1 because they are not clearly legible and can be studied at leisure when the illustration is printed, but you will notice on the left at the bottom that the average water-cement ratio for the gravel mixtures, with the plain cement, was 6.08 gallons per bag, and the average for all stone mixtures was 7.16. In other words, the crushed stone accepted the penalty of over a gallon per bag more water than was required by the gravel.

The average water-cement ratios with cement containing flake Vinsol resin are shown in the next column (I might interpolate here that the amount of flake Vinsol resin was 0.03 per cent); the average for the gravel mixtures was 5.58 gallons per bag; and for stone 6.43—the difference was not quite so great as with the plain cement; being 0.85. For the 0.01 per cent neutralized Vinsol resin it was 5.61 for the gravel as compared with 6.35 for the stone, with the difference again decreasing to 0.74. With the 0.02 neutralized Vinsol resin, the water cement ratios were 5.42 as compared with 6.06, a further decrease in differential to 0.64; but in all cases the crushed stone required a higher W/C than did the gravel due to its harshness even in the cubical shape. The actual cement contents differed with the air entrainment, because no correction was made in this program for the bulking effect of the entrained air, but they are basically comparable.

FIGURE 2

CR-NVR Program

Influence of Vinsol Resin (Type and Amount) on Properties of Plastic Concrete

Coarse Aggregate	Cement	Voids, Per Cent				Bleeding, Per Cent				Slump, Inches				Remolding Time, Seconds			
		Plain	VR	NVR 0.01 %	NVR 0.02 %	Plain	VR	NVR 0.01 %	NVR 0.02 %	Plain	VR	NVR 0.01 %	NVR 0.02 %	Plain	VR	NVR 0.01 %	NVR 0.02 %
Gravel	A	1.3	4.3	3.6	6.4	11.4	5.2	9.6	7.2	2.2	2.3	2.4	2.9	6.8	6.1	8.1	7.7
"	B	2.0	5.1	4.0	5.6	14.3	7.2	10.4	10.1	2.25	2.2	2.0	2.25	6.8	7.0	8.8	7.7
"	C	2.6	10.0	4.7	6.5	6.0	2.6	3.5	2.3	2.5	2.9	1.9	1.9	7.1	4.9	8.6	10.1
"	D	1.5	4.3	4.9	7.5	6.0	2.6	5.1	2.7	2.7	3.1	2.9	2.8	7.2	7.4	6.9	6.9
"	E	2.0	5.5	4.9	7.0	4.6	2.9	2.2	1.6	1.9	2.7	2.1	2.0	8.7	6.6	8.3	9.2
Stone	A	2.7	6.3	5.1	8.0a	15.0	7.1	19.3	10.3a	2.25	3.2	3.0	3.2a	6.2	5.2	8.4	8.0a
"	B	2.1	4.7	4.8a	7.3	19.6	15.2	15.9a	15.4	2.0	2.6	3.0a	2.6	8.0	7.6	8.2a	8.5
"	C	4.1	14.1	5.7	9.0	13.0	3.1	4.4	3.4	2.8	3.7	1.75	2.25	6.4	4.8	12.5	10.7
"	D	2.7	4.8	4.9	9.8	11.8	7.1	11.9	5.7	2.9	2.75	3.0	3.1	7.3	7.4	10.4	6.5
"	E	2.8	6.3	6.4	9.6	7.8	6.1	5.0	3.1	2.3	2.9	2.7	2.6	7.3	8.0	11.2	9.2
Aver. for Gravel Mixes...		1.9	5.8	4.4	6.6	8.5	4.1	6.2	4.8	2.3	2.6	2.3	2.4	7.3	6.6	8.1	8.3
Aver. for Stone Mixes....		2.9	7.2	5.4	8.7	13.4	7.7	8.3	7.6	2.4	3.0	2.7	2.7	7.0	6.6	10.1	8.6

Note: All values shown are straight averages of three determinations, except the eight marked "a", which are averages of four determinations.

FIGURE 3

CR-NVR Program

Influence of Vinsol Resin (Type and Amount) on Compressive Strength of Concrete in Terms of the Strength of Normal Untreated Cement

Coarse Aggregate	Cement	Compressive Strength Age 3 Days*				Compressive Strength Age 7 Days*				Compressive Strength Age 28 Days†			
		Plain	VR	NVR 0.01 %	NVR 0.02 %	Plain	VR	NVR 0.01 %	NVR 0.02 %	Plain	VR	NVR 0.01 %	NVR 0.02 %
		%	%	%	%	%	%	%	%	%	%	%	%
Gravel	A	100	87	73	70	100	101	101	86	100	99	99	95
"	B	100	92	80	70	100	86	96	88	100	83	95	92
"	C	100	62	100	94	100	66	110	103	100	87	96	90
"	D	100	104	95	88	100	100	96	92	100	99	103	105
"	E	100	89	106	97	100	95	97	98	100	101	95	86
Stone	A	100	89	70	92	100	89	94	84	100	94	115	100
"	B	100	88	79	65	100	94	91	90	100	95	103	100
"	C	100	64	126	97	100	68	146	125	100	86	131	114
"	D	100	109	107	91	100	112	116	101	100	105	117	100
"	E	100	84	99	76	100	85	98	90	100	78	90	77
	Aver. of Gravel Mixes	100	86	90	83	100	91	100	93	100	92	97	91
	Aver. of Stone Mixes	100	86	95	83	100	89	107	96	100	91	109	97

Note: * Values shown are averages of three specimens. † Values shown are averages of two specimens.

The sand-aggregate ratios varied with the cement treatment and with the type of aggregate. That is an important feature in the design of concrete using an air-entraining agent.

I would like to urge that you not follow the all too frequent concept that the mixture should be *re-designed* for air-entraining cement. You *design* for it. You start from scratch. I think it would be well to separate entirely in your mind and in your policy the connection between plain portland cement concrete and concrete containing an air-entraining agent. They are different things and must be dealt with differently.

Figure 2 shows the influence of the Vinsol resin and the types of aggregate on the properties of the plastic concrete. The factor of immediate concern is the voids, or the entrained air. Keep in mind, now, that the differences in water-cement ratio shown in Figure 1 are maintained throughout, although they are not repeated in the remaining illustrations. For the plain cement it will be noticed that the gravel mixtures averaged 1.9 per cent air, and that the air in the stone mixtures was 2.9 per cent. The stone mixtures have a tendency to entrain more air than does the gravel concrete. Do not be concerned too much about the amount of air shown in Figure 2, because that is a function of the mixing procedure. It happens that in this program a 3.5 cu. ft. tilting mixer was used with an initial mixing period of three minutes, then a rest period of three minutes, and then a final mixing period of one minute. The idea of the rest period was to get away from any tendency that might exist toward flash set which would influence the air determinations and the bleeding and various other characteristics that we were anxious to study without the influence of a flash set.

With the flake Vinsol resin, the stone again had a tendency toward entrainment of about 1.4 per cent more air than the gravel; and with the 0.01 neutralized Vinsol resin the gravel concrete entrained an average of 4.4 per cent; the stone 5.4 per cent. Now, in this case I would like to refer to the fourth column in the body of the table which shows the voids for flake Vinsol resin cement. You will notice there that one of the cements, Cement C, entrained a very considerably greater amount of air than did the other four, both for the gravel concrete and for the stone concrete. That is the particular hazard in the use of flake Vinsol resin. That particular cement is highly reactive with Vinsol resin. You will notice that when the neutralized Vinsol resin is added, there is no such great difference in air entrainment with the various cements.

You will note, too, that with only 0.01 per cent of the neutralized Vinsol resin, the air entrainment was only slightly less than it was with 0.03 per cent of the flake Vinsol resin, and that the air entrainment obtained with flake Vinsol resin is bracketed between the 0.01 neutralized and the 0.02 neutralized, so that perhaps with about 0.015 of neutralized Vinsol resin about the same amount of air as was entrained by the flake Vinsol resin might have been obtained.

In the very important factor of bleeding, the stone mixtures do not compare favorably with the gravel mixtures, and the reason is the considerably higher water-cement ratio which was necessary for use with the stone. The gravel concrete averaged 8.5 per cent bleeding and the stone concrete averaged 13.4 per cent. That is a pretty high bleeding, and you will notice the reduction in bleeding due to the use of the Vinsol resin. I would like to impress you at this point with the fact that those who claim that concrete made with air-entraining cement will not bleed are overstating the case. The best that any air-entraining agent can do is to reduce the tendency toward bleeding. If the cement is inherently a bad bleeder, the concrete is still going to bleed if you use air-entraining cement, but it will bleed considerably less.

Strength

Figure 3 shows the effect of the Vinsol resin and the types of aggregate on the compressive strength of the concrete at various ages. The strengths here are expressed as percentages rather than as real values because we are more interested in relativity than in the absolute in these cases. All of the strengths are referred to the comparable plain cement mixture. It will be noted that even though the crushed stone was penalized by the higher water-cement ratio, the strengths are comparable with the gravel mixtures. At three days, with flake Vinsol resin, they both were 86 per cent of the plain cement. With 0.01 neutralized Vinsol resin, the gravel was 90 per cent and the stone was 95 per cent, showing slightly superior strength with the stone mixtures even with the higher water content. With the 0.02 neutralized resin, the strengths of the gravel and the stone mixtures were comparable.

The basic comparability of strength holds at all ages with flake Vinsol resin, but with the 0.01 neutralized Vinsol resin the stone mixtures were

FIGURE 4

CR-NVR Program

Influence of Vinsol Resin (Type and Amount) on the Flexural and Compressive Strength of Concrete

Coarse Aggregate	Cement	Flexural Strength, psi.* (Age 28 Days, Air-Cured)				Flexural Strength, psi.* (Age 28 days, Fog-Room Cured)		Comp. Strength, psi. 28-Day Cyl.† Fog-Room Cured	
		Plain	VR	NVR 0.01%	NVR 0.02%	PLAIN	VR	0.01% NVR	0.02% NVR
Gravel	A	385	380	425	415	480	430	4110	3755
"	B	415	370	415	385	520	450	3830	3455
"	C	410	375	445	435	440	400	4290	4030
"	D	400	390	425	375	460	480	3465	3280
"	E	445	405	430	450	440	440	4135	3565
Stone	A	420	360	480	420	510	490	3350	3160
"	B	460	415	470	355	520	490	3520	3125
"	C	380	350	455	465	440	340	4250	3645
"	D	380	400	445	385	450	480	3180	2955
"	E	445	395	450	435	470	450	4040	3365
	Aver. of all Gravel Mixes	410	355	430	410	470	440	3965	3615
	Aver. of all Stone Mixes	415	385	460	415	480	450	3670	3250

* Average of three specimens. † Each value is an average of six specimens.

FIGURE 5

Influence of Type of Cement and Type of Coarse Aggregate on Durability of Concrete as Tested at Experimental Exposure Station No. 1 Treat Island, Maine

Series CR-NVR

Durability Factor DFE[1] at 142 Cycles

Cement Type	Addition to Cement							
	None		VR		0.01 NVR		0.02 NVR	
	Type of Coarse Aggregate							
Mill	G[2]	S[3]	G	S	G	S	G	S
A	38	123	120	130	122	121	122	125
B	34	119	121	128	116	120	117	118
C	120	130	136	140	115	97	116	123
D	70	139	129	142	118	121	116	123
E	122	125	128	138	115	118	112	117

[1] In terms of Relative Modulus of Elasticity. See CCL–C 20–44. [2] Long Island Siliceous Gravel. [3] Crushed Trap Rock, Conn.

stronger at 28 days than the plain cement and the gravel mixtures were only slightly less strong at that age.

Figure 4 shows the effect of the Vinsol resin and the type of aggregate on the flexural and compressive strengths of concrete, in this case using real values. I might well have used relative values here, too, because the strengths are not as high as you might expect. The reason is that we were not basically interested in this characteristic and the specimens that were tested were vertically cast columns and not the traditional cylinders or horizontally cast beams, and curing in fog was not maintained to 28 days. But the relativity still holds.

For the plain cements, the strengths were comparable, with the gravel mixtures being slightly stronger. With the flake Vinsol resin, the strengths were lower than the plain cement concrete and the stone mixtures were stronger than the gravel mixtures. The mixtures containing neutralized resin were stronger than those with plain cement, both with the gravel and the stone. We have found that by the proper use of air-entraining cement and proper design of the mixture that it is not necessary to sacrifice strength materially, either in flexure or in compression.

Flexural strengths at 28 days of fog-cured columns are shown in the center columns of Figure 4 for certain conditions. The compressive strengths of fog room-cured cylinders shown at the right indicate that the strength of the gravel mixtures for this group of specimens is somewhat greater than that of the stone mixtures.

Durability

We have at Treat Island, Maine, in the Bay of Fundy (which is just as far north and east as you can go in the United States and still stay in it), a major research installation where we take columns of concrete 6 in. by 6 in. by 4 ft. long and install them at the mean tide elevation and permit them to be thawed by immersion in the water and then frozen by exposure to the air. We use the installation at Treat Island not for a sea water exposure but for a natural rapid freezing and thawing exposure. The waters of the Bay of Fundy never get colder than about 36 degrees, but the air gets much colder than that, so every time the tide covers the specimens it thaws them, and every time the tide goes down the specimens are frozen. There is nothing standardized about the cycle because the air temperature, of course, varies very considerably, but we get approximately 160 cycles of freezing and thawing up there a year.

The specimens referred to in Figure 5 were exposed in the fall of 1943, so at the time these data were set up they had gone through only 142 cycles

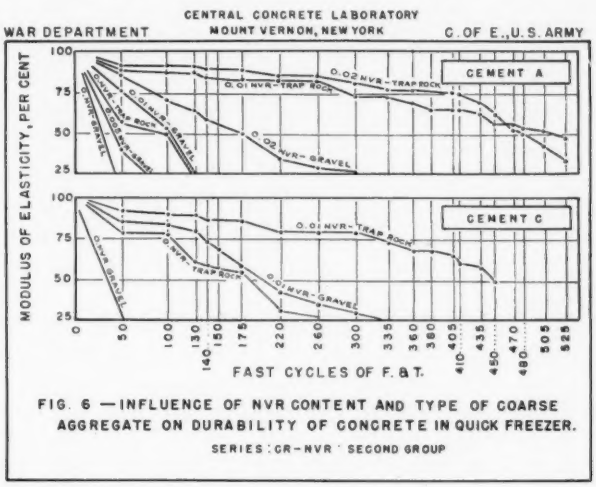

FIG. 6 — INFLUENCE OF NVR CONTENT AND TYPE OF COARSE AGGREGATE ON DURABILITY OF CONCRETE IN QUICK FREEZER.
SERIES: CR-NVR · SECOND GROUP

FIGURE 6

of freezing and thawing. They have not reached an end point, but there is a definite relationship between the durability of the gravel concrete and the stone concrete in the column marked "none," meaning no air-entraining agent. It will be noted that the durability of the gravel concrete is far less good than that of the stone concrete in three of the five cases, and is less good than the stone concrete in the other two, but the difference is not so marked. I might state that the reason for the differences may be because Cement C has a high-air-entraining characteristic even though no conscious addition of an air-entraining agent is made in its manufacture. But it does show the influence of air entrainment even when it is an unconscious addition.

Where flake and neutralized Vinsol resin were used, there is no marked decrement in the durability; which we have come to expect as natural. I might explain that the durability factor is a function of the decrement in the dynamic modulus of elasticity of the concrete.

Figure 6 contains data which I am sure will cheer you very much, indeed, but I hope that you do not tie to it too definitely. The graphs show the results of freezing and thawing in the laboratory with two of the five cements. It will be noted that the top

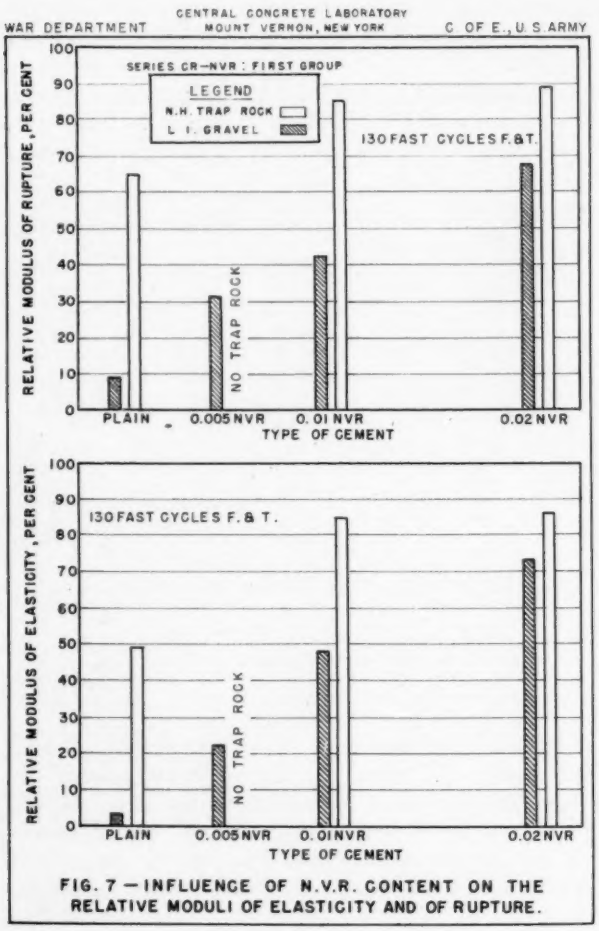

FIG. 7 — INFLUENCE OF N.V.R. CONTENT ON THE RELATIVE MODULI OF ELASTICITY AND OF RUPTURE.

FIGURE 7

curve for Cement A, marked 0.02 neutralized Vinsol resin with trap rock, is comparable in durability to the 0.01 neutralized Vinsol resin with trap rock. In other words, no significant improvement in durability came with the addition of twice as much of the air-entraining agent, and they both are far and away more durable than any of the other materials used. The gravel concrete with 0.02 neutralized Vinsol resin reached 25 per cent of the original modulus of elasticity at 300 cycles, whereas neither of the trap rock concretes had reached that decrement in 525 cycles, although they were approaching it.

The fourth curve is 0.01 neutralized Vinsol resin with gravel, and the fifth is trap rock with no air-entraining agent. At the end point, at about 130 cycles, their durability was comparable. That is quite an achievement for the trap rock penalized by a higher water-cement ratio.

The last two curves in the lower left are the gravel with no Vinsol resin and with only 0.005 per cent of neutralized Vinsol resin. The addition of some neutralized Vinsol resin did improve the durability, but not to a significant degree.

In the family of curves for Cement C the 0.01 per cent neutralized Vinsol resin with trap rock was far and away the most durable and it only reached a decrement of 50 per cent at 450 cycles. The 0.01 per cent neutralized Vinsol resin with gravel had reached 25 per cent at about 330 cycles; and it is interesting to note that again the trap rock with no addition of an air-entraining agent had a roughly comparable durability to the gravel with the 0.01 per cent of neutralized Vinsol resin, and that the gravel with no air-entraining agent was not very durable. With these particular conditions, the trap rock concrete was about as durable as gravel was with neutralized Vinsol resin added, even though the water-cement ratio of the trap rock was significantly greater than that of the gravel.

Figure 7 illustrates by bar graphs the relative durability of the mixtures in terms of the relative modulus of rupture and the relative modulus of elasticity for the type of cement, and the amount of the air-entraining agent used in the gravel and the trap rock mixtures. In both of the graphs, which are very similar, the improvement in the durability of the concrete by the addition of the Vinsol resin is not nearly so great with the trap rock as it is with the gravel, and it will be noted that the disparity in durability between the gravel and trap rock with plain cement is profound; whereas when 0.02 per cent of

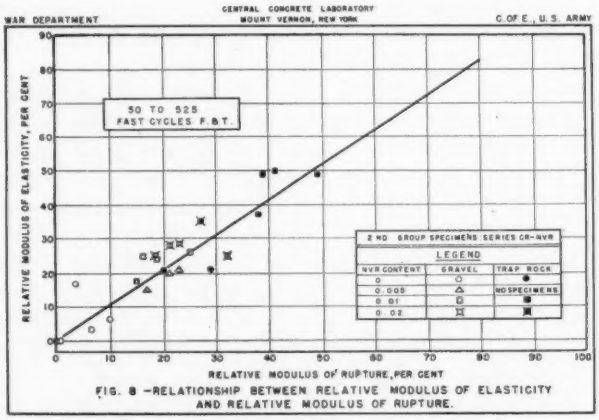

FIG. 8 —RELATIONSHIP BETWEEN RELATIVE MODULUS OF ELASTICITY AND RELATIVE MODULUS OF RUPTURE.

FIGURE 8

neutralized Vinsol resin is used the difference is not so great although it is still significant.

Both of those graphs are included because a number of persons have questions in their minds about the propriety of using the dynamic modulus of elasticity as a measure of durability of concrete. It seems to be an intangible value, sort of an academic or theoretical usage, so we, among others, have attempted to correlate the decrement in dynamic modulus with the actual rupture strength of the concrete, and you will see that these graphs are very similar, indeed.

Figure 8 illustrates this relationship differently, yet it will be noted that even though the data presented were based on from 50 to 525 cycles of freezing and thawing of gravel and trap rock mixtures with and without Vinsol resin, that the relationship between the relative modulus of rupture and the relative modulus of elasticity is exceedingly good. I think that epitomizes the validity of the so-called sonic test. Others have found this comparable relationship.

Figure 9 is included as sort of a literary purple patch in this particular presentation, because you will hear more about it in the future. It has been my most urgent desire for a number of years to make it possible to determine the durability of the ingredients of concrete by tests of concrete containing them. We have devised at the laboratory an automatic freezing and thawing apparatus with a considerable capacity, which makes possible twelve cycles of freezing and thawing in a 24-hour period without "being touched by human hands". The specimens are placed in a chamber and the refrigerant is pumped and circulated around them automatically for a period of an hour, during which time their temperature is reduced from approximately 45 F. to approximately zero F. At the end of that period, the refrigerant returns to the cold tank and the thawing solution is pumped around the specimens in the specimen chamber and in the period of an hour their temperature is again elevated to approximately 45 degrees. These reversals are continued automatically.

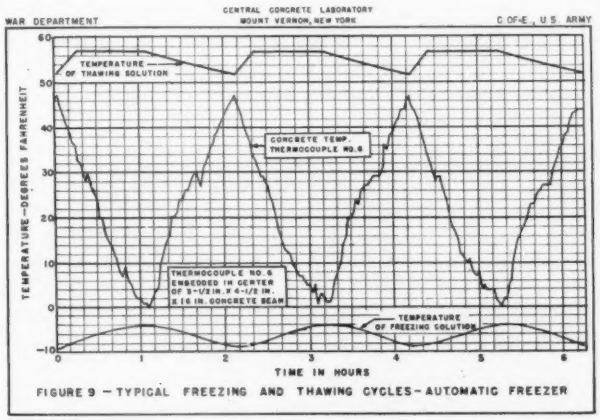
WAR DEPARTMENT
CENTRAL CONCRETE LABORATORY
MOUNT VERNON, NEW YORK
C. OF E., U. S. ARMY
TEMPERATURE OF THAWING SOLUTION
CONCRETE TEMP. THERMOCOUPLE NO. 6
THERMOCOUPLE NO. 6 EMBEDDED IN CENTER OF 5-1/2 IN. X 4-1/2 IN. X 16 IN. CONCRETE BEAM
TEMPERATURE OF FREEZING SOLUTION
TEMPERATURE—DEGREES FAHRENHEIT
TIME IN HOURS

FIGURE 9 — TYPICAL FREEZING AND THAWING CYCLES — AUTOMATIC FREEZER

FIGURE 9

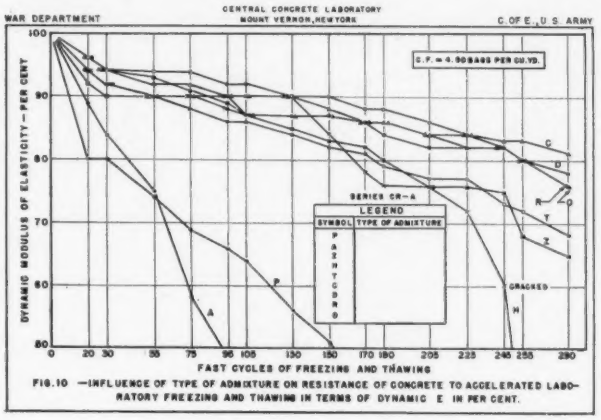

FIG. 10 —INFLUENCE OF TYPE OF ADMIXTURE ON RESISTANCE OF CONCRETE TO ACCELERATED LABORATORY FREEZING AND THAWING IN TERMS OF DYNAMIC E IN PER CENT.

FIGURE 10

The top curve in Figure 9 indicates what happens to the thawing solution during the cycle: the temperature is reduced from about 55 F to about 52 F. The bottom curve shows what happens to the refrigerant: it is elevated in temperature from approximately – 9 F to approximately – 4 F. The zigzag curve in the middle shows what happens at the center of gravity of the concrete specimen as determined by a thermo-couple imbedded in the concrete. The cycle is recorded on a Brown recording potentiometer and continues day in, day out, Sundays and holidays, and permits us to obtain 200 cycles of freezing and thawing in adequate time to judge the acceptability of the material in the normally available 28 days of the test period. Prior to completion of this equipment, one could never tell how long it would take to determine the relative durability of a material in concrete. Sometimes in the past we have frozen specimens for over two years before we could get significant differences in their durability.

Figure 10 departs from the program of which I have been speaking and gets into a newer program that we have been conducting to determine the acceptability of other air-entraining agents than Vinsol resin which might affect the durability of concrete.

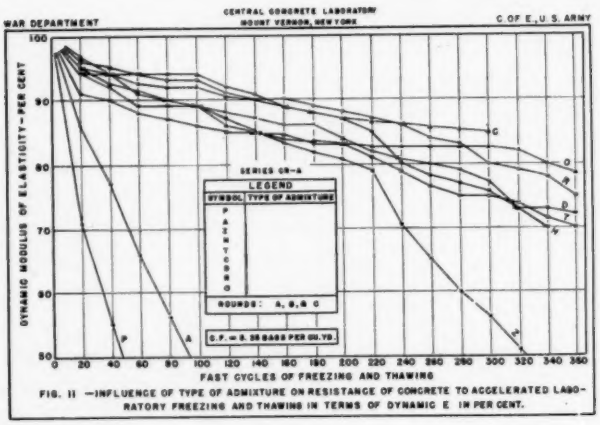

FIG. 11 —INFLUENCE OF TYPE OF ADMIXTURE ON RESISTANCE OF CONCRETE TO ACCELERATED LABORATORY FREEZING AND THAWING IN TERMS OF DYNAMIC E IN PER CENT.

FIGURE 11

In this program we had switched from gravel as the standard aggregate to crushed stone so a lot of the durability that is present is attributable to the aggregate and not only to the air-entraining agent.

I am not at liberty at this time to disclose the identity of all the various admixtures used. The letter "P" represents plain cement without any admixture, and it will be noted that with the exception of one admixture, all of the others had a profoundly beneficial influence on the durability of the concrete; this concrete being made with a cement factor of 4.5 bags per cubic yard. The letter "R" represents neutralized Vinsol resin added as a solution at the mixer. It will be noted that at 280 cycles there had been a rather considerable decrement in the modulus of elasticity. Heretofore we have taken similar concrete to well over a thousand cycles without appreciable distress being noted.

Figure 11 is similar except that the cement factor was 5.25 bags per cubic yard.

The accelerated freezing and thawing test has been brought into this paper, because we are going to do all that we can do rapidly to amass sufficient background to permit its use for the acceptance of aggregate in the type of concrete that might be used in the project for which the material was submitted. We will not do this prematurely. We will attempt to obtain a very considerable amount of data based on a number of aggregates collected from widely separated locations in this country. It will probably be at least a year, or maybe longer, before we are able actually to base acceptance on the results of this test.

Effect of Mixing Time

I am sure that all of you, as well as all others interested in the technology of concrete, have been concerned with the tendency, or the apparent tendency, of so-called air-entraining cement to increase in its air entrainment with prolonged mixing time. We have been concerned about that, too, and have been doing our best to correct it or find means of avoiding it. Figure 12 shows the results of some tests that we have made to determine just what the influence of mixing time was on the entrained air, using the various types of cement included in the program first mentioned in the paper. The curve on the upper left shows the air entrained by the plain cements without the use of an air-entraining agent. It will be noted that there is no tendency toward increase in air entrainment with mixing time. As a matter of fact, there is an ultimate tendency toward a slight reduction in air entrainment. It will be noted, too, that one of the cements (Cement C) entrains a total of about 3.1 per cent air in a five-minute mixing period.

The curves in the upper right of Figure 12 show the influence of mixing time on the entrainment of air when interground flake Vinsol resin is used. The curve at the top is again Cement C which reacts so markedly with Vinsol resin. In five minutes, it has entrained almost 12 per cent air and then begins to drop off. This dropping off characterizes all of the mixtures with which we have had experience. It reaches a maximum, holds for a while, perhaps, and then drops off.

The other three cements continue to gain in air content up to 15 minutes, or thereabouts, but at a slower rate than did Cement C, indicating that there is no particularly standard way in which the air entrainment will be effected, but there is a definite tendency toward increased air entrainment with continued mixing time which would affect the ready-mixed-concrete industry.

The curves in the lower right section of Figure 12 show the influence of neutralized Vinsol resin when interground with the cement. There is a markedly reduced tendency on the part of three cements toward the entrainment of air with continued mixing. Even Cement C entrains considerably less air with continued mixing time than it did when interground with flake Vinsol resin.

The curves at the lower left of Figure 12 show the effect of adding neutralized Vinsol resin to the cement at the mixer. It will be noted that in no case

is there a tendency toward the increase of air entrainment with mixing time at the longer periods. The maximum air is achieved at the 1½ to 3-minute mixing period. There is some increase between 1½ and 2 minutes. After that, it either holds or tends gradually to drop off. I would like to rationalize that in so far as I am able to. The flake Vinsol resin, I will review, depends on reaction with the cement during the period in which it is present in the mixer. The neutralized Vinsol resin is not dependent upon this reaction, but when it is added to the cement at the mill, it is subject to the temperature of grinding, which softens it, and there is a tendency toward adsorption of the resin on the surfaces of the particles of the cement. In this adsorbed state it is not as available for solution as it would be had it not been adsorbed. When the neutralized Vinsol resin is added to the cement at the mixer, it is able to perform its function without any of the extraneous factors such as adsorption being present.

I think that is important and it explains the change in my attitude with respect to air entrainment. I am convinced that the practice of air entrainment affords a tremendous improvement in the technology of concrete. We intend to pursue our studies toward perfection of the practice. We are not accepting anything as final and we may even change farther than we have changed already, but we have already changed our policy from insisting that Vinsol resin be interground with the cement at the mill to insisting that neutralized Vinsol resin be interground at the mill, and now we plan to make it optional with the contractor whether the air-entraining agent is interground with the cement or whether it is added at the mixer. This is still a transitional phase. I do not know where we will go from there; whether or not we will go to the point of requiring that the admixture be added at the mixer, but it is my impression from the tests we have made most recently, and which are not yet complete, that the potentialities of air entrainment will most nearly be completely realized in the future with the addition at the mixer rather than with addition at the mill.

There are some practical difficulties on both sides. When the air-entraining agent is added at the mill, under the present specifications, the amount added is controlled by a mortar test. In other words, with a standard mortar the air-entraining agent shall not entrap in the mortar more than 14 plus or minus 4 per cent air. On work done very largely by our laboratory, we had reason to believe that the relationship between the air in the mortar and the air in the

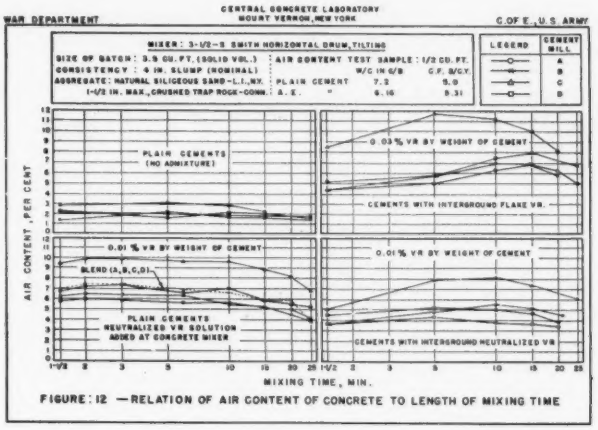
WAR DEPARTMENT
CENTRAL CONCRETE LABORATORY
MOUNT VERNON, NEW YORK
C.OF E., U.S. ARMY
MIXER: 3-1/2-S SMITH HORIZONTAL DRUM, TILTING
SIZE OF BATCH: 3.5 CU. FT. (SOLID VOL.)
CONSISTENCY: 4 IN. SLUMP (NOMINAL)
AGGREGATE: NATURAL SILICEOUS SAND - L.I., N.Y.
1-1/2 IN. MAX., CRUSHED TRAP ROCK - CONN.
AIR CONTENT TEST SAMPLE: 1/2 CU. FT.
W/C IN G/B
C.F. B/C.Y.
PLAIN CEMENT 7.3 5.9
" 6.16 5.31
LEGEND
CEMENT MILL
A
B
C
D
PLAIN CEMENTS (NO ADMIXTURE)
0.03 % VR BY WEIGHT OF CEMENT
CEMENTS WITH INTERGROUND FLAKE VR.
0.01 % VR BY WEIGHT OF CEMENT
BLEND (A, B, C, D)
PLAIN CEMENTS NEUTRALIZED VR SOLUTION ADDED AT CONCRETE MIXER
0.01 % VR BY WEIGHT OF CEMENT
CEMENTS WITH INTERGROUND NEUTRALIZED VR
AIR CONTENT, PER CENT
MIXING TIME, MIN.
FIGURE 12 —RELATION OF AIR CONTENT OF CONCRETE TO LENGTH OF MIXING TIME

FIGURE 12

concrete would be about 3 to 1, so that we would get in our concrete an air content of approximately 4 to 5 per cent. The limited experience we have had with cement so controlled in field concrete indicates that no such clear relationship exists. Perhaps, we had a hood over our eyes when we thought that such a simple relationship could exist, because we were neglecting one of our basic precepts of design which is,—that the type of aggregate, the amount of cement, the consistency, the water-cement ratio, all affect the characteristics of the concrete, so to believe that a mortar test could determine definitely what the air entrainment of concrete would be was rather wishful thinking. However, it must be stated and emphasized that dependence upon the mortar test has afforded a definitely improved control over that obtained previously by a quantitative limit on the amount of the air-entraining agent to be used.

Generally, we have found that the ratio between the air content of the standard mortar and field concrete is closer to 5:1 rather than 3:1, but, there may be other cases when the ratio will be less than 3:1. So, the control of air entrainment in concrete must still remain in the hands of the engineer. When cement is ordered with an interground air-entraining agent, the manufacturer does his best to make the type of air-entraining cement that is desired. When the first shipments arrive on the job it may be found that the concrete to be used does not possess the amount of air-entrainment desired. While some adjustment of the air content is possible by a redesign of the mixture, the degree of adjustment is usually small, so the only alternative is the rejection of the cement and the procurement of a new supply. Sometimes blending at the mill is possible, sometimes not,

but in any case the operation of obtaining the proper air-entrainment is costly to the manufacturer and costly to the contractor because it occasions delay in the progress of the work and speed is of the essence of any construction contract. If a material is added at the mixer, it can be varied from batch to batch, if necessary.

The disadvantage on the side of adding the admixture at the site of the work is the disadvantage which has attached itself to the word "admixture" for as long as I have been connected with concrete, that is, the onus of "too little or too much". There are classic instances when a certain amount of admixture was required to be used but it was forgotten in the forenoon so double the quantity was added in the afternoon so that at the end of the day it would balance out. There are other cases, too, which were not quite so simple as that; where the admixture would have to be added in a cup, dipper or bucket and the addition depended on some well-wishing but not too interested operator's reaching into a bag or barrel and dumping the allotted amount in the batch.

Obviously, the admixture must be added at the mixer by as completely automatic and mechanical a means as is now used for the addition of any other ingredient of the concrete. It has to be raised to the dignity of a basic ingredient of the mixture, and there is no reason at all why this cannot be accomplished in a manner similar to the addition of cement to the batcher. I think it is certainly well within the realm of the ingenuity of the American equipment manufacturer to devise such practical means of insuring the accurate and dependable addition of even very small amounts of the admixture at the mixer.

Up to now we have been placed in the position of choosing to use air-entrainment with an acceptance of the possibility of some reduction in that highly important, perhaps too highly important, factor of strength. We have said we want the air-entrainment, because it will improve the durability of the concrete. It will also most assuredly increase the placeability of the concrete. It will also reduce the bleeding of the concrete. It will also increase the coherence of the mixture. But, some have felt that these desirable features must be obtained at some sacrifice in strength. Some believe that the reduction in strength may be about 25 per cent. We have found that usually the reduction is not in excess of 10 per cent if the admixture and the mixture are well controlled, but always there is that feeling of some compromise.

With neutralized Vinsol resin we have higher hopes that we can get closer to absolute parity but there is no reason why the practice of air-entrainment should ever be tied to a compromise or to parity. There is no reason why proper accelerators could not be interground with, or added to, or mixed with the air-entraining agent; in other words, there is no reason why the air-entraining agent should be used alone, and when it is added to the mixer the possibilities are without limit as to what can be done in the compounding of an admixture. In our work we have developed and used an admixture which produced the air-entrainment desired

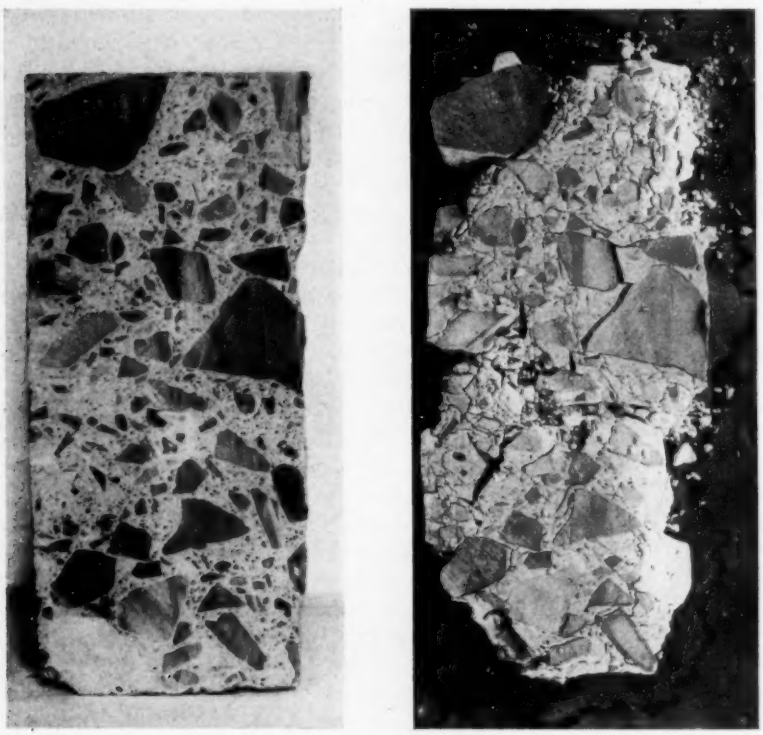

FIGURE 13
Core 30-B-3 Before F & T.
Core 30-B-3
Shows complete disintegration after 19 cycles of F & T.
Freezing and Thawing Test—Dale Hollow Dam Cores
(Cores eight inches in diameter)

and the durability was even greater than has been obtained previously with even neutralized Vinsol resin when used alone, the strength was improved significantly, and most importantly, the bond to steel was greatly improved as compared with similar concrete made with plain cement; so I think the future of air-entrainment is very great, and I think that the future of the use of crushed stone in concrete is very great, too.

Figure 13 is included to illustrate that concrete is not necessarily the more durable for having crushed stone used as the coarse aggregate. The concrete shown is an 8-in. diameter core, sawed longitudinally, removed from a dam. The composition of the concrete is acceptable by all ordinary criteria. However, it was observed that this and other similar cores commenced to develop minute hair cracking on standing in the laboratory. On exposure to normal freezing and thawing in the laboratory, in a moist but non-immersed condition, the development of cracks was greatly accelerated until the complete deterioration indicated in the view on the right occurred after 19 cycles.

Figure 14 shows the rupture of the mortar matrix surrounding the coarse aggregate in the same concrete. The nature of the original cracks and of the ultimate disintegration indicated that the failure was associated with the aggregate, but no actual failure occurred in the aggregate particles. Heating and cooling tests indicated that a basic differential existed between the thermal properties of the aggregate and of the cementing matrix. Determinations indicated that the thermal coefficient of expansion of the aggregate was abnormally low (about 2.2 x 10^{-6}) as compared to the value usually associated with concrete (6 x 10^{-6}), but it was not simple to determine the coefficient of the matrix.

It is apparent from this and other concrete studied that the thermal properties of the aggregate are prime factors in the influence of an aggregate type on the durability of concrete. It happens that there was good compatibility between the thermal coefficient of expansion and thermal diffusion of the aggregate and the matrix of the concrete in the program of tests on which this paper is principally based and that no such compatibility exists in the concrete (Figures 13 and 14) taken from the dam.

I believe that in cases where a considerable number of structures have shown distress in the past and

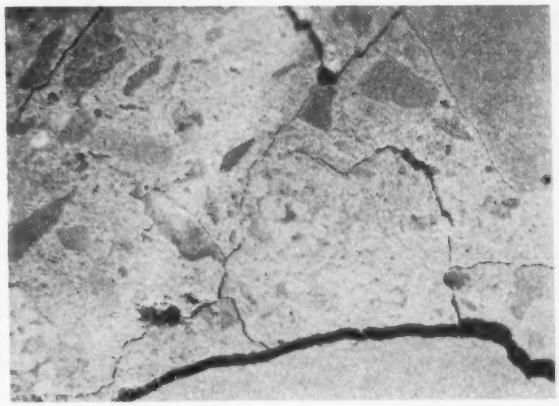

FIGURE 14

Typical appearance of mortar after ten cycles of F & T. Magnification 10X.

Freezing and Thawing Test—Dam Cores
Shows development and type of cracking.

that distress has been attributed to the cement or to the aggregate, or to frost, it may have been due largely to incompatibility between the aggregate used and the cementing matrix. Perhaps, that is projecting the technology of concrete into the future, but I would like to leave with you the thought that your researches should be directed toward the study of the thermal properties of concrete from a practical standpoint, not only in massive concrete, but in any structure. If the coarse aggregate will change volumetrically in a different manner and degree than the surrounding matrix you are bound to have trouble.

In closing, I wish to say that it has been decided, on the basis of the tests reported here, to permit concrete to contain as much as 0.5 gallons per bag of water more than is normally specified when a good crushed stone is used. This may be slightly dangerous, because we may find ourselves using crushed stones which are not as good as the one that we used in the tests, but I think it is a proper step to take in recognition of the data which we have. However, we have to be far more conscious of the problem of the thermal properties of the aggregate and of the concrete, and we intend to be.

Finally, I would like to ask again that you not depend too much on others for basic information so important to the welfare and progress of your industry. I would like to see a national organization of all aggregate producers dedicated to research and development of aggregate for concrete with facilities adequate for the work.

Trends in Asphaltic Pavements[1]

By BERNARD E. GRAY

General Manager-Chief Engineer
The Asphalt Institute
New York City

• **Asphaltic pavements are of special interest to crushed stone producers, for stone possesses characteristics which make it outstandingly fitted for successful use in this type. The construction methods employed influence success or failure and it is timely to have a forward-looking, constructive paper presented, containing ideas for the improvement of the asphaltic type as in the following discussion by a well known authority, Bernard E. Gray.**

THE other day I had a letter from a Professor of the University of South Africa, referring to a conversation which he had had with a South African engineer just returned from a short visit to the United States. This engineer had made the statement that a considerable change in the manner of using asphalt was taking place here and had concluded from his rather brief contacts that cut-back asphalts were no longer favored because the new work he saw was of plant-mix type. He also had heard that asphalt cement of 200-300 penetration was being used in hot-mix work in place of harder asphalts.

I cite this incident to indicate the difficulty of exactly predicting trends in construction practice and that one's view depends upon the angle from which the field is surveyed, the background which an individual has had in the way of personal experience, and an appraisal of the material, labor, and equipment developments which bear upon the situation. Of course, this South African engineer was incorrect in his too definite appraisal of the situation. In 1944, well over two million tons of cut-back asphalt were produced in the United States (equivalent to some six hundred million gallons), while the greater portion of paving asphalts were much harder than 200 penetration. He evidently had visited only a few construction projects, and, while it was a fact that on those particular projects certain changes were taking place as contrasted with previous work done in the same area, he had drawn general conclusions which were extreme and, unless qualified, gave an incorrect view of the situation.

There have been a number of developments during the war period, however, which will exert a profound influence on future paving operations in this country, and it is about some of these changes and perhaps indicated trends that I wish to talk this morning. To some extent the comment of the South African engineer was true. There is a trend toward the greater use of plant mix, and it is a fact that whenever any type mixture is processed in a plant, a higher viscosity binder can be used than when the processing is done on the ground by mixed-in-place methods. Accordingly, there likewise is to be noted a definite trend toward the use of higher viscosity liquid asphalts (or even soft asphalt cements) in place of the more liquid products which were in general use prior to the wide availability of: (1) mixing plants of great flexibility of operation, and (2) mechanical spreading equipment in the number which has come into use because of war activities.

However, this is but a trend, and the amount of work which will be accomplished by road-mixing and surface-treatment operations will continue to be of large amount. In fact, it will be as great or greater in volume in the foreseeable future as at any time in the past. The thousands of miles of secondary roads which will be stepped up to a higher level of usefulness alone will guarantee such a trend, while the large amount of accumulated maintenance necessary to rehabiliate the present system (which has been allowed to suffer under the restrictions of wartime) will for the next few years call for the complete utilization of all equipment available for these types of work.

In addition to catching up on maintenance, there is the need for reconstruction of a large part of the primary system, and this will be immediately even more important than the much-talked-of regional highway construction program so far as providing quickly the facilities required for postwar traffic. This regional highway program will be confined to a limited mileage, whereas the rehabilitation program needed over the entire primary ssytem will be many times as great in length. Much of such work on the primary system will be accomplished with

[1] Presented before the 28th Annual Convention of the National Crushed Stone Association at New York, January 31, 1945.

plant-mix types of asphalt mixtures because of the numerous advantages afforded by such procedure.

One such advantage is the ability to place resurfacing over one-half roadway width, while traffic is carried over the other half without need for detour. Another advantage is immediate use of the resurfaced area, as no curing period is required. It is frequently the practice to surface one half the roadway in the morning and then to carry traffic over it in the afternoon of the same day while the other half is being surfaced. Along with resurfacing the old pavement, there often will be need for widening at the same time. While a majority of primary highways have proper alignment, many of them are too narrow to safely carry tomorrow's traffic.

There are miles of 18- and 20-foot pavements, however, which can be widened readily to 22 or 24 feet and, when so widened, will adequately serve traffic for many years to come. One of the problems formerly had in widening work was to prevent settlement of this widened area, but today special roller equipment is available whereby even a one-foot-wide strip can be compacted to such degree (using asphaltic concrete) that, when resurfacing is placed over both the old pavement and the widened area, the desired cross section of completed pavement will be maintained as constructed without differential settlement.

This trend toward use of plant-mix surfaces had become quite pronounced before the war, but the need for large-scale paving of new roads, streets, and airports in connection with the war effort has accelerated this trend to a marked degree. It also has brought out certain weaknesses in both design and construction procedures, which, while previously recognized, had nevertheless been tolerated because satisfactory work was being obtained, as a rule, under the prewar conditions prevailing.

In the postwar era, asphaltic concrete will be used not only in highway resurfacing, but also in the construction of the new heavy-duty highways on the Regional Highway system, the facing of dams, the lining of storage reservoirs, the revetting of river banks, the construction of jetties, the stabilizing of railroad ballast, plus a great number of smaller individual items of use for private industry and on the farm.

Two principal reasons may perhaps account for this great potential expansion. One is the availability of plant equipment which brings down the cost of finished mixtures to the lowest competitive level in history. Asphalt pavements in the past have been rarely over three inches in thickness. We shall see many miles of asphaltic concrete pavements built in the next few years of six-inch thickness. The other reason is to be found in the development of chemical treatments, which will insure the coating of wet and hydrophilic aggregates with asphalt so that the film or binder cannot be removed under the most adverse conditions. This technological development is obviously of the greatest importance and opens up a vast field of new work which has not been practicable before. For example, a jetty can be built by dumping the asphalt mix directly on the bottom of ocean or river bed, even at considerable depth, and building up the required section until it is above water at the finished elevation. By control of the qualities of the mix, such work can be accomplished without need of forms and yet will be dense, waterproof, and durable. The advantages of such procedures are obvious, and the development is mentioned to indicate some of the new methods of asphalt construction which are to come.

To control the production of mixtures so that the finished work shall have the required qualities, it is apparent, however, that specifications will have to be revised, expanded, or even completely rewritten. For many years construction agencies have been using specifications which have been borrowed one from another, dating back to the original specification written by some long-forgotten engineer. At the original writing they may have adequately served the needs of that time. Adapted to new situations, they often have been anything but accurate or even completely descriptive.

However, engineers and contractors generally had become familiar with what was expected in a given area, and work was done in a reasonably successful manner, although more by mutual consent than because of the specifications. The war produced a distinct shock in this particular. Engineers who had grown familiar with operations in a given area suddenly were transferred to new locations. Likewise, contractors became engaged in work in distant areas under an entirely different group of engineers and for the first time, perhaps, found themselves in some difficulty as to what was expected from the specifications governing the new jobs.

Now this situation is the fault of the specification writer, and it is high time that nearly all of our paving specifications were completely overhauled and made to say what they are intended to say and not be merely page after page of garrulous verbiage. Perhaps one example with regard to paving opera-

tions will illustrate the general situation. Let us take the seemingly simple item of rolling. Just for curiosity, I reviewed the specifications of some fifteen states, each one of which does a large annual volume of asphalt paving. Almost without exception, these specifications state that the course shall be rolled until thoroughly compacted and to the satisfaction of the engineer.

Now, what kind of a specification is that? It is a clause that has been in general use for years and yet, when examined critically, is in reality an expression of ignorance. The only reason that it has worked is because of mutual tolerance on the part of the contractor and the engineer, who in effect have agreed that, when they run a roller up and down so many times, the course is thoroughly compacted in accordance with the intent of the specifications. Actually, this may or may not be the case. Sometimes it is compacted and sometimes it is not compacted, and practically all of the troubles which at times have arisen with the construction of stone bases and pavements have resulted from differential settlement, most of which could have been prevented by proper control of construction operations. As far as that is concerned, the same criticism could apply equally well to preparation of the subgrade, or placement of the subbase or base course, regardless of the type of wearing surface.

Some efforts at better control have been attempted in the past, but often they have not kept pace with changes in equipment. For example, in respect to rolling, there is sometimes a provision whereby the time during which a roller shall operate over a given yardage is specified in about the following language, "Rolling shall proceed continuously at the following rates per hour per roller:

surface course—not in excess of 150 square yards
binder course—not in excess of 300 square yards
base course—not in excess of 200 square yards."

Provided the rollers operated more or less continuously and with due regard to the stopping of the old steam roller to take on water and coal, this was a fair requirement. However, with the general adoption of the gasoline roller and the mechanical spreader, such requirements were clearly in excess of the needs of the situation because the mechanical spreader produced a certain amount of consolidation, while the longer time of actual operation of the gasoline roller—due to elimination of delays in taking on water and coal—meant that far more compaction was obtained in a given time than had been previously the case. However, it was several years before specifications were even partially altered to meet the improved construction conditions. In fact, many public agencies still use the same specifications they did twenty years ago. To indicate the change brought about by equipment alone, it is to be noted that rolling time is now only about one half that previously required, everything else being the same.

However, it is obvious that such attempts at control are but half measures and that the specification should be written something like this, "Rolling shall be continued until *some standard of quality has been achieved.*" Now, what are these standards of quality? First, a pavement must have the uniform strength contemplated from selection of the type. With any type of concrete, whether bituminous or portland cement, this quality of strength can be measured in terms of flexure and shear. For unbound or weakly cemented structures, such as base courses of macadam and other selected aggregates, the desired strength with any specified quality of materials will have been obtained when consolidation and compaction processes have produced some given minimum density.

This item of rolling is taken merely to emphasize the obligation which rests upon engineers so to write the details of construction specifications that even a new inspector can obtain the quality of work required, and yet with all fairness to the contractor so that the latter is required to do only that amount of work needed to achieve the desired end result. With such objectives, and based upon studies of service behavior so as to know what these minimum requirements should be, The Asphalt Institute is completely revising construction specifications with view to elimination of all indefinite, general requirements. It is proposed to provide that asphalt mixtures, as placed in the street, highway, airport, revetment, jetty, or whatever paving work, shall meet certain strength and density standards. It is apparent that in setting up such standards the methods of field test must be relatively easy and capable of being carried on as a routine matter, or else the whole purpose is defeated. It is also apparent that there have been difficulties in the way of carrying on such tests in the past, or else these indefinite provisions in specifications would not have been permitted to remain.

What are the present methods of making these tests and how conveniently can they be carried on? Experience has shown that, if an asphaltic concrete pavement resists lateral movement under the heavi-

est loading and remains waterproof under the most adverse weather conditions, it will be durable and adequately serve the needs of traffic for which it is designed. This ability to resist lateral movement is a resistance in shear, and hence the test for this quality is a type of shear test, viz., the so-called stability test.

To have a pavement waterproof, it is necessary that it shall be of such density that water cannot penetrate into the interior of the compacted mixture. From a study of trial mixtures, a job mix can be selected which will have these waterproof qualities—as represented by some per cent of voids after compaction. Experience has shown that hot-mix asphaltic concrete will be waterproof if the compaction process produces a finished pavement with less than 6 per cent voids.

To have the density and stability tests truly reflect field conditions, it is, of course, necessary that samples be taken from the finished pavement if their behavior is to be the criterion of when adequate compaction has been secured. Tests on laboratory samples alone are not sufficient. Therefore, it has been necessary to devise suitable equipment for taking samples from the pavement and in such a manner that the resultant cylinders or briquettes are representative of the actual condition of the pavement. Also, the cylinders must be kept in such a form as to be easily handled without damage until after the testing is completed.

A simple cutting tool has been devised whereby cylinders 6 inches in diameter and up to 6 inches in thickness can be obtained quickly and intact so that samples can be secured every few hours if required. There is a field laboratory usually at all asphalt plants. The empty trucks returing for load can bring the samples to this field laboratory, and the density and stability tests can be run as routine procedure. All questions as to whether the pavement (*as being laid*) meets specifications would thereby be resolved without delay, and the matter of rolling would be a question of fact and not guesswork.

Now for another change, and it would seem to be a logical one. If the contractor can devise a procedure which will obtain the required density in one half the time formerly required by conventional equipment, that is his good fortune, and he should be permitted to make use of it. If by more efficient use of conventional equipment he can do the required placement in less than average previous records, he should derive the advantages that come from such enterprise. It is believed that there is much room for improvement in type and use of compaction equipment and that substitution of a quality measurement of the end product for the uncertain clause, "in the judgment of the Engineer," is an essential forward step to encourage such development.

I have used this item of rolling purely as one example. Perhaps a brief comment on another aspect of the conventional asphaltic concrete specification may provoke further discussion. Often there is much emphasis placed upon a given gradation of aggregate as a criterion of quality. I am not judging other specifications only in this comment because to some extent our own specifications have had similar restrictions. I believe, however, that there is much opportunity for greater flexibility in respect to gradation controls; changes which would in no way injure quality and would often lead to lower costs.

As noted previously, any asphalt pavement that is stable and waterproof is likewise durable. Consequently, *any gradation of aggregate* that will meet these requirements should be satisfactory from a service standpoint. Only when surface texture is a criterion is there real need for more exact specification of aggregate gradation, and even here limitation of maximum size would usually take care of the situation.

It is well known that gradation by itself is not a true indication of stability. The fact that a certain composition of mixture produces a given stability with one aggregate is no indication that it will have the same value when using another aggregate. Each kind of aggregate has its own peculiar characteristics and behavior, and the only way to determine its behavior is by making trial mixtures and measuring their ability to take shear when at the required density.

In other words, requirements for composition of mix should be rather wide, but requirement for behavior of the mixture as placed in the pavement should be very definite. In the writing of new specifications, this latter requirement should be the important one, and consistent with its attainment considerable latitude could be allowed a contractor in setting up the design of a mix. However, once the job mix has been set for a given aggregate supply, rigid control in respect to uniformity of plant operation should be insisted upon, with definite tolerances as to allowable deviation.

There are a number of stability tests, any one of which is suitable when properly employed. They

include the Hubbard-Field test, the Hveem stabilometer test, the Marshall test, the triaxial shear test, and others. Such tests are not only a means of laboratory design, but they are equally well a means of control of plant operation. Through their use, it is possible to set up the standards of value which are needed to meet a given service condition. Correlated with service history, it is possible to predict whether a given mix of the desired density and a certain stability will be adequate for a given traffic.

For example, there can be the secondary road with relatively light-volume, light-unit traffic and only an occasional heavy truck. For such conditions, a surface course having a Hubbard-Field stability of 1500 might be entirely adequate. On the other hand, a primary highway having heavy-volume, heavy-unit traffic might require a stability of 2000 or 2500 in open country and as much as 3500 on particularly heavy-duty streets with numerous stop lights and a considerable volume of solid-tired trucks.

In other words, the design control of mixtures should be by means of measuring the strength of the finished pavement, and not simply rely on composition of mixture alone. The establishment of the exact gradation curve should come after the strength and density standards have been worked out in the laboratory.

This whole matter of design and inspection procedure has become increasingly important with the large increased use of asphaltic concrete, extending into many areas where engineers now are handling such work for the first time and where many new aggregates are being used. The Asphalt Institute has in preparation a complete new manual covering such subjects as: (a) how a mixture is designed, (b) how plant operation is controlled, (c) methods of test, (d) inspection procedure, and (e) standards of quality. We believe that this text will serve a useful purpose, for it will reflect a most careful study of the subject by the asphalt industry.

Conclusion

Perhaps I might summarize my entire paper in a few short sentences:

(1) There is a definite trend toward the greatly increased use of asphalt plant mix, not only on highways and airports but also on railroad work, water and erosion control, and on the farms.

(2) Nevertheless, because of accumulated maintenance and a greatly expanded secondary road program, surface-treatment and mixed-in-place types of asphalt surfacing will continue in large volume.

(3) The perfecting of various methods whereby wet and hydrophilic aggregates may be so coated that the asphalt films are completely resistant to stripping not only will correct the difficulties experienced with certain aggregates in conventional paving operations, but also will open many relatively new avenues of use of asphaltic mixtures.

(4) A most important development will be the rewriting of asphaltic concrete specifications whereby definite qualitative standards for the finished work shall be established. Many loosely worded clauses in respect to such items as spreading and rolling can and should be eliminated, with appropriate methods of field test substituted in their place. The tables of composition of mixtures, while making full use of commercial aggregates manufactured to comply with Simplified Practice standards, nevertheless should be sufficiently flexible in range so that the contractor may exercise his ingenuity in developing a job mix that will be lowest in cost to produce, so long as it complies with required standards for density and stability when ready for use.

Converted Liberty Ships Ferried Vehicles for European Campaign

Specially converted Liberty ships have ferried 133,654 vehicles from England to the Continent since D-Day, the Transportation Corps has disclosed.

Known as "Motor Transport Vessels," the Liberties had four of their five hatches modified for handling of vehicles. Each MTV carries an average of 124 vehicles and 272 men in addition to its crew.

Before D-Day the MTV's were ordinary Liberty ships, making normal runs between ports in the British Isles and the United States. As plans for the invasion took shape, the need for a type of vessel which could carry large numbers of vehicles was recognized. These vessels would supplement LST's and LCT's, whose use was limited by the number of loading "hards" available. It was decided to convert some Liberty Ships.

Weeks before D-Day, dock workers started making the changes. Lashings and other equipment to prevent the heavy vehicles from rolling when the vessel was at sea were installed. The fifth hatch was equipped in order to sleep the 272 men who were to accompany each load of vehicles.

How Facts Help Sales[1]

By A. T. GOLDBECK

Engineering Director
National Crushed Stone Association

• **Crushed Stone is a product which is successfully used in many different ways, frequently involving intricate processes of a technical nature. It is advantageous for the salesman to understand these various uses and the characteristics of stone best suited to the work. The present paper, based on past experiences, shows how the salesman is helped by a knowledge of technical facts and methods.**

IT WOULD seem to be almost axiomatic that any salesman should have as wide a knowledge of his product as possible. Applied to the crushed stone salesman, this means that he should know the characteristics and properties of crushed stone; how these are tested; what the tests signify; how his particular stone, because of its special properties can best be used; how these properties influence the proportions of concrete or bituminous mixtures in which it is used in combination with other materials. In fact, he should have full knowledge regarding his product. Such knowledge is more or less expected of him because he is supposed to be a specialist in the material he is selling.

Let us take a look at some of the various ways in which the use of knowledge concerning the various phases of crushed stone really does aid the salesman in the sale of his material.

By knowing the effects of its physical and chemical characteristics he will be able to seek out those markets for which his product is best adapted. Let us amplify that statement. One of the physical characteristics of crushed stone is its angular shape. This very angularity, if not carried to excess, is really a decided asset to crushed stone, especially when it is used in macadam base construction, in bituminous concrete and bituminous macadam, and likewise for use in railroad ballast. When angular crushed stone is closely interlocked as it is in these various types of construction, internal movement within the mass of stone is accomplished with extreme difficulty. That is just one way of saying that a mass of angular stone is very stable. This is a point to be emphasized in the sale of stone for these purposes. Most crushed stone salesmen are aware of the truth of the statement that angularity produces stability, but that is not enough. Each salesman probably can cite instances in his own locality showing the relative stability of stone as compared with other materials and he should endeavor to get into his files some definite instances of this nature. Furthermore, he should be able to turn to references in the literature which he could use to prove his contention. Facts certainly are better than mere assertions. They are most effective in proving some definite point upon which the sale depends.

One very important property of crushed stone is its specific gravity, the weight of stone as compared with the weight of an equal volume of water, but I wonder how many salesmen are fully aware of the usefulness of this particular physical value in connection with their sales work. It is useful in a number of different ways, for it is this value which controls, to a major extent, the weight of stone having a given gradation. It can be used in connection with calculations concerning portland cement concrete, bituminous concrete and macadam, for estimating the quantities necessary.

When materials are closely competitive, one with another, and these materials have different specific gravities, a knowledge of how to make use of specific gravity calculations may well clinch a sale which otherwise might be lost. It is for this reason that in our short courses for salesmen we have laid great stress on this property and its use in calculations concerning concrete. Applied to different coarse aggregates, such calculations show with great exactness what the differential in sales price may have to be to make the sale successful. I say to all crushed stone salesmen that they will never regret the time necessary to gain the facts and methods which will permit them to use specific gravity calculations with facility. I can conceive of no fundamental test value made in connection with crushed stone which has higher importance to the crushed stone salesman. The lack of knowledge regarding this property and its use can well lead to the loss of many a sale.

Gain and use the facts regarding the extraordinary value which crushed stone has for use as an aggregate in concrete highways. Why is it that crushed stone concrete pavements seem to have such an outstanding value? That is a subject which could well be discussed for several hours, for it involves a num-

[1] Presented at the Twenty-Eighth Annual Convention, National Crushed Stone Association, Hotel New Yorker, New York City, January 29-31, 1945.

ber of considerations, among them being good mechanical bond with the matrix or mortar portion of the concrete, and, in general, relatively low thermal coefficient of expansion, which results in relatively lower thermal stresses in most crushed stone concrete. Each aggregate is an individual material and it is highly essential that the salesman get the facts for his own crushed stone as compared with his competing materials, facts, for illustration, such as the relative beam strength or modulus of rupture of concrete made with the various competing aggregates.

If possible a record of the relative service behaviors of the various aggregates in his vicinity should be obtained. Facts such as these are very convincing and in many cases will influence a sale in favor of his stone. Certainly they influence the type of specification which is set up by public bodies concerning concrete proportions for different types of aggregates. I know this to be true for I have seen it happen in national and state specifications and I have seen crushed stone deliberately singled out as the material to use in important concrete pavement work as against competing aggregates, entirely due to its superior qualities. This general superiority of crushed stone as an aggregate in concrete pavements should be emphasized by the crushed stone salesman, but he should gather all the information he can with reference to his particular aggregate for use in pavement work as compared with competing aggregates.

I wonder how many salesmen use the well-authenticated facts applying to crushed stone as an aggregate in fireproof building construction? These facts, in general, are very favorable to most types of stone, particularly as compared with the siliceous type of gravel which is most prevalent among the gravels. Important national codes recognize this difference in aggregates and salesmen should be familiar with the extent of this recognition and make use of it in upholding the sale of their stone for use in building construction. We have the facts available within our Association and we have published many of them and we have tried to emphasize their importance in the two schools we have held for crushed stone salesmen.

When a local building code is being written salesmen might well remind the building authorities of the known differences in fire resistance of concretes made with different coarse aggregates and the necessity of recognizing these differences in their code. The use of the facts regarding fire resistance will help to promote the sale of crushed stone through the writing of proper building codes.

Stones differ in their chemical composition to a very considerable extent and of course it is now well known that the chemical composition controls the usefulness of some types of stone for certain purposes. Particularly is this true of the high calcium limestones. In all probability salesmen connected with most companies having high calcium limestone are well informed as to the possible markets for materials of this nature, but every once in a while new markets are discovered; new chemical uses are developed which require the use of high calcium stone. Study is required on the part of salesmen to discover the many ways in which high calcium limestones can be used and I believe that such study will be effective in showing the way to new markets for their products. The use of the facts in this case should be very productive in promoting new sales.

Another very important way in which the use of facts by salesmen can be indirectly productive in promoting sales is in bringing about more effective cooperative effort between production and sales. The salesman must know the kind of material that should be produced and the production department should keep the salesman informed of the inherent difficulties in the production of different sizes of materials. The salesman comes into contact with the user of his material, the man who writes the specifications, and such men are frequently not at all familiar with the production problems. The consequence is that at times specifications are written which are impracticable from the production standpoint. The salesman, by making use of his knowledge of what is practicable in the production department can do much to see that proper specifications are written. By cooperating with other salesmen in adjoining localities, he can help to bring about a simplification of sizes so that simpler production will result; a better understanding will develop between salesmen and consumer; fewer rejections will result because the specifications are made more practical and sales will then not be hampered because of the difficulty of meeting them. Obviously, the facts of the case are necessary to aid sales in this manner. When the facts are thus used, however, they surely will expedite the sale of crushed stone.

Specifications for highways and other types of construction frequently contain clauses which, though innocent appearing in themselves, sometimes not only react against the sale of stone, but may actually make it impossible to use stone in the con-

struction covered by the specifications. I have in mind, for illustration, specifications for concrete which set up a given minimum cement factor, but also a limitation on the maximum allowable quantity of water per bag of cement. A number of specifications of this type really exclude stone from use, because the maximum allowable water content per bag of cement cannot be met in stone concrete unless a very much higher cement factor is used than with more rounded aggregate. This of course means that it is extremely difficult for stone to compete with certain rounded gravels. Such specifications might almost just as well be written saying that stone shall not be used in the construction. A knowledge of concrete proportioning is necessary in order that the salesman may recognize harmful specifications of this nature. Obviously, when he does have a knowledge of the facts, he can make use of them to bring such inequities to the attention of specification writing bodies to show why the harmful clauses should be eliminated. Stone may be a very superior aggregate for the type of construction concerned even though it is eliminated by the specification for concrete proportions. Here is a case where knowledge by the salesman will repay him many fold.

A particularly well informed salesman can frequently give advice as to the best type of construction for a particular purpose on the basis of knowledge which he has acquired from past experience. I have in mind several cases of this kind in which stone salesmen have been able to give excellent advice to the engineer in charge of the design of certain projects with the result that the advice has been followed and excellent and very satisfactory construction has been obtained. The use of stone screenings for parking areas, even on soil which has very poor supporting capacity, has been advocated in several instances by certain stone salesmen with highly satisfactory results. Also, the great advantage of using screenings as a blanket layer under macadam base course has been pointed out by salesmen; their advice has been followed and the results have been excellent. It is entirely true that many salesmen are not in a position to offer advice of this kind on the basis of their own experience, but at least they can obtain information from other salesmen who have had the necessary experience. I am sure that it would be freely given.

In one case a well-informed salesman was able to suggest the proper design for a flexible runway for an airport carrying the heaviest type of plane built today. His advice was essentially followed. I have examined spots on the runway where a B-29 landed and where it stood for several days. There was no evidence of indentation due to this heavy load. This was a highly technical service offered by the salesman and our Asssociation was fortunately able to cooperate with him to the extent of checking his proposed design.

To my mind there is another and a very important way in which salesmen can make use of facts to promote the sale of stone. The alert salesman in the course of his travels and contacts with others will frequently see the need for the construction of projects. Notwithstanding his particular and selfish interest in desiring that these projects be constructed. I see nothing wrong in his urging their desirability before the properly constituted authority. A recognition of the need of such projects, whatever they may be, and a conception of their type and character require knowledge and their adequate presentation cannot be made without supporting facts. So, I say to you again, it is necessary that the salesman be armed to the greatest extent possible with an array of facts which will permit him to encourage needed construction. If he is successful the result will be the promotion of the sale of his or someone else's material. But let the project be a worthy and useful one.

Some companies distribute pamphlets or circulars containing facts which advertise the merits of their particular stone. This is an avenue of sales promotion which is open to every company and which undoubtedly is effective, not so much in the sale of stone on contracts for public construction, but rather in connection with private work. Quite obviously, in order to produce an effective piece of advertising literature, the pertinent facts regarding the merits of a particular stone must be known, but when those facts are known and properly presented there can be no doubt that the way is eased for the final sale of the material.

Conclusion

I have not attempted to present the detailed facts which a salesman should have, for this would require a very extensive discussion, but it must be obvious to anyone that by gaining a full knowledge of his material and by using that knowledge in the ways I have indicated, and undoubtedly there are many more ways, the sale of crushed stone will be augmented. It is plain from what has been said that the crushed stone salesman is of a high type and he

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Lack of Plans Jeopardizing Highway Program

By CHARLES M. UPHAM
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Washington, D. C.

THE future of American highways and the solution of our unemployment problem squarely rests upon the amount of road projects we have ready to put into operation when the war ends. During the first postwar year, we propose to build more than a billion dollars worth of roads—primary, secondary and municipal. This is the program under the Federal-Aid Highway Act of 1944 which authorized $500,000,000 for the purpose to be matched dollar-for-dollar by the states, counties and cities.

With the need great and with funds available, we might well imagine all out state and local highway departments busy as beavers turning out blueprints, writing specifications and doing all those engineering tasks which must be done before contracts can be let and the actual work started. Unhappily this is not the case. Only eight states have sufficient plans ready to make an adequate start; and this lethargy and delay may jeopardize the entire postwar program. It is a matter that concerns every reader of this publication for the condition of the nation's highways affects all of us no matter where we live or what we do. The answer is to appeal to those charged with preparing plans to get busy immediately.

Authorities agree that if one billion dollars in construction work is proposed, there should be at least twice that amount in plans in order to give flexibility to the program. With a choice possible, the first jobs can be started where the demand for employment is the greatest. We have plans for a road at Smithville and at Jonesburg. But Smithville has no unemployment, while at Jonesburg men are idle and hungry. Naturally it is the Jonesburg project which should first receive attention. The Smithville job can come later. But if the Smithville job is the only job we have, we face a truly grave situation. So let's plan that Jonesburg job at once.

Findings of a survey by the American Road Builders' Association reveal only $685,000,000 in plans now completed and these concentrated largely in eight of the forty-eight states. Those are serious figures to consider. Only a little more than two-thirds of the actual construction to be done, and one-third of the plans we should have to avoid bottlenecks. No wonder the people who drive cars and ship by truck are concerned. It is high time that something be done about it by our highway users.

The war is already over in Europe and prospects for victory in the Pacific are bright. Hostilities may terminate swiftly. Are we going to be caught one-third of the way to our goal? That eventuality is not pleasant to think about. It means wasteful, extravagant and unfruitful "made work", unemployment, depression. It should not happen again and highway construction planning is the way to prevent it.

Some highway departments complain that manpower is the cause of their attitude, but let us see what others have done. With true American ingenuity, a number of states have overcome the shortage of highway employees in a variety of ways. Some have employed women at the drafting board and even in the field. This has proved satisfactory, we are told.

Others have called in private engineering firms and this too has worked out well. Some have used engineering students to good advantage, the students receiving credit in their class work and pay for their time. Retired highway employees have been recalled for the emergency, and the payment of overtime for employees, not a common practice in highway departments, did much to step-up plan production. One state is proud of the fact that it has trained high school students to perform the duties of a highway department drafting room. These diverse ways of beating the manpower shortage are not copyrighted. There's no reason why all the states should not use them.

Then too former highway employees or young men with engineering experience which can be adapted at once to highway department requirements are returning daily from the war zones. Government agencies in Washington report that an appreciable number of such potential rodmen, draftsmen and technicians are now available. They should be used.

In order to present a complete case against delay, it should be added that federal funds have been set

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Agricultural Limestone Division of NCSA Formed

HENRY A. HUSCHKE
Managing Director

RESPONSIVE to a recent and growing demand among producers of agricultural limestone there has been formed an Agricultural Limestone Division of the National Crushed Stone Association. Initial action was started at the time of the annual convention last January when after a full discussion of the matter the Board of Directors authorized the Executive Committee to proceed with the formation of an Agricultural Limestone Division, in order that the interests of agricultural limestone producers might be more fully and effectively served. Aware of the effort currently being made to form a National Agricultural Limestone Association, and believing that it would be unfortunate to have two organizations endeavoring to serve the same field, a determined but unsuccessful effort was made to bring the two groups together on a mutually acceptable basis.

The Executive Committee then proceeded to develop a plan for the formation of a Division and submitted such plan for consideration to a representative group of agricultural limestone producers at a meeting in Cincinnati, Ohio, on April 5 and 6, 1945. After giving most thoughtful consideration to the various factors involved, it was decided at this meeting, without a dissenting vote, that the interests of agricultural limestone producers could best be served through the formation of an Agricultural Limestone Division of the National Crushed Stone Association.

Division is Self-Governing

The Agricultural Limestone Division of the National Crushed Stone Association is self-governing. It has its own Chairman, Executive Committee, and Board of Directors. By-Laws of the Division will permit it to formulate its own policy, establish its own budget and rates of dues; and, in general, be master of its own affairs, all of course within the framework of the Articles of Incorporation and By-Laws of the National Crushed Stone Association.

The By-Laws of the Division provide for a Board of Directors of not to exceed thirty-five, including the Chairman and the five Regional Vice Chairmen; and an Executive Committee of eight. At the organizing meeting in Cincinnati the following were elected to the Board of Directors and to the Executive Committee to serve for the interim period until such time as circumstances permit the holding of an industry-wide meeting of the Division.

Board of Directors

Howard M. Thomas, *Chairman*, Fort Scott Hydraulic Cement Co., Ft. Scott, Kans.
Paul I. Detwiler, New Enterprise Stone & Lime Co., New Enterprise, Pa.
Earl L. Dingle, Harry T. Campbell Sons Co., Inc., Towson, Md.
John Durrell, Hoosac Valley Lime Co., North Adams, Mass.
James Eells, Basic Dolomite, Inc., Cleveland, Ohio
Otho M. Graves, General Crushed Stone Co., Easton, Pa.
E. E. Haapala, Zumbrota, Minn.
P. E. Heim, Carbon Limestone Co., Youngstown, Ohio
L. W. Hayes, Hayes Construction Co., Kansas City, Mo.
E. L. Heckathorn, Stuntz and Yoeman Lime Quarry, Delphi, Ind.
R. P. Immel, American Limestone Company, Knoxville, Tenn.
E. J. Krause, Columbia Quarry Co., St. Louis, Mo.
S. J. Marks, Material Service Corporation, Chicago, Ill.
A. W. McThenia, Acme Limestone Co., Fort Spring, W. Va.
Verne C. Morgan, Kentucky Stone Co., Louisville, Ky.
S. P. Moore, Concrete Materials and Construction Co., Cedar Rapids, Iowa
Robert Murphy, Black Creek Stone Co., Black Creek, Wis.
Paul M. Nauman, Dubuque Stone Products Co., Dubuque, Iowa
Norbert Neuheisel, Neuheisel Lime Works, Eau Claire, Wis.
W. M. Palmer, Dixie Lime Products Co., Ocala, Florida
W. T. Ragland, Superior Stone Co., Raleigh, N. C.
A. B. Rodes, Franklin Limestone Co., Nashville, Tenn.
E. V. Scott, Southwest Stone Co., Dallas, Texas
C. M. Sims, Campbell Limestone Co., Gaffney, S. C.
O. M. Stull, Liberty Limestone Corp., Buchanan, Va.

R. T. Willingham, Willingham-Little Stone Co., Atlanta, Ga.

Executive Committee

HOWARD M. THOMAS, *Chairman*

PAUL I. DETWILER	R. P. IMMEL
E. E. HAAPALA	E. J. KRAUSE
P. E. HEIM	NORBERT NEUHEISEL

Henry A. Huschke Employed as Managing Director

In order to immediately undertake the accomplishment of the objectives outlined in the program of activities for the Division, the Board of Directors appointed Henry A. Huschke as Managing Director of the Division effective May 1, 1945.

Mr. Huschke is known to many in the industry as the former manager of the Agricultural Department of the National Lime Association, where he gained a broad experience in promoting the practice of soil liming. Since March 1942 he has been employed as a Business Specialist in the Office of Price Administration. In that capacity Mr. Huschke had under his jurisdiction pricing problems relating to agricultural liming materials and fertilizer raw materials. He graduated from Cornell University in 1922 and since that date has been engaged in commercial fields closely related to agriculture. Mr. Huschke undertakes the program of activities of the new Division with enthusiasm and the realization that it is a big job which needs to be done soundly and well.

Comprehensive Program Formulated

The program of activities that is being undertaken is as follows:

1. *Government.* Contacts will be maintained with all government agencies, both state and federal, whose programs or acts have a bearing upon the industry.

2. *Agronomy.* The Division will keep in touch with the research activities of the various state experiment stations and will arrange joint conferences between member companies and the personnel of the state colleges and experiment stations.

3. *Promotion.* A vigorous educational program will be undertaken. This will take the form of booklets, pamphlets, charts, film strips and the like, for distribution by member companies.

4. *Bank Loans.* The Division will encourage local bankers to extend, and farmers to use, long-term bank loans to finance the purchase of agricultural limestone. It is generally recognized that the full returns from the use of limestone accrue over a period of years. This makes the capital outlay for limestone unattractive unless long-term financing can be arranged.

Copies of the booklet which presents this program have been mailed to a large list of producers and distributors of agricultural limestone. Its favorable acceptance is evidenced in the number and type of firms that, at this early date, have applied for membership.

How Facts Help Sales

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requires a great deal of specialized knowledge of his product and the ways to use it to the best advantage.

It is clear that to promote the sale of stone, many avenues of approach are open and the pursuance of these avenues leads to crushed stone sales. Quite evidently, however, to effectively travel them, facts must be acquired and used to the best advantage. Facts do help sales. I urge on every salesmen the desirability of his acquiring as many facts concerning his own particular material and its uses as he can possibly obtain. With those facts at his command, I firmly believe that present avenues of sales approach will be broadened and others will be revealed which, hitherto, have been unsuspected.

Lack of Plans Jeopardizing Highway Program

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aside in the Act of 1944 for financing highway plans. This removes the last barrier that might be holding up essential planning.

Planning affects every state for each needs many hundreds of miles of roads. Those that have been the most negligent have announced that their requirements far exceed the mileage that can be built from funds allocated for the first three postwar years. A big job lies ahead.

Every citizen, every taxpayer, every motorist in the land should concern himself seriously with the highways of the future. He should assist his state and local highway officials in every way possible. He should let these men know that he is interested in their problems and that they have his support. The postwar highway program is vital to everyone. Ask your highway officials if there is any way you can help.

MANUFACTURERS' DIVISION

of the

NATIONAL CRUSHED STONE ASSOCIATION

These associate members are morally and financially aiding the Association in its efforts to protect and advance the interests of the crushed stone industry. Please give them favorable consideration whenever possible.

Allis-Chalmers Mfg. Co.
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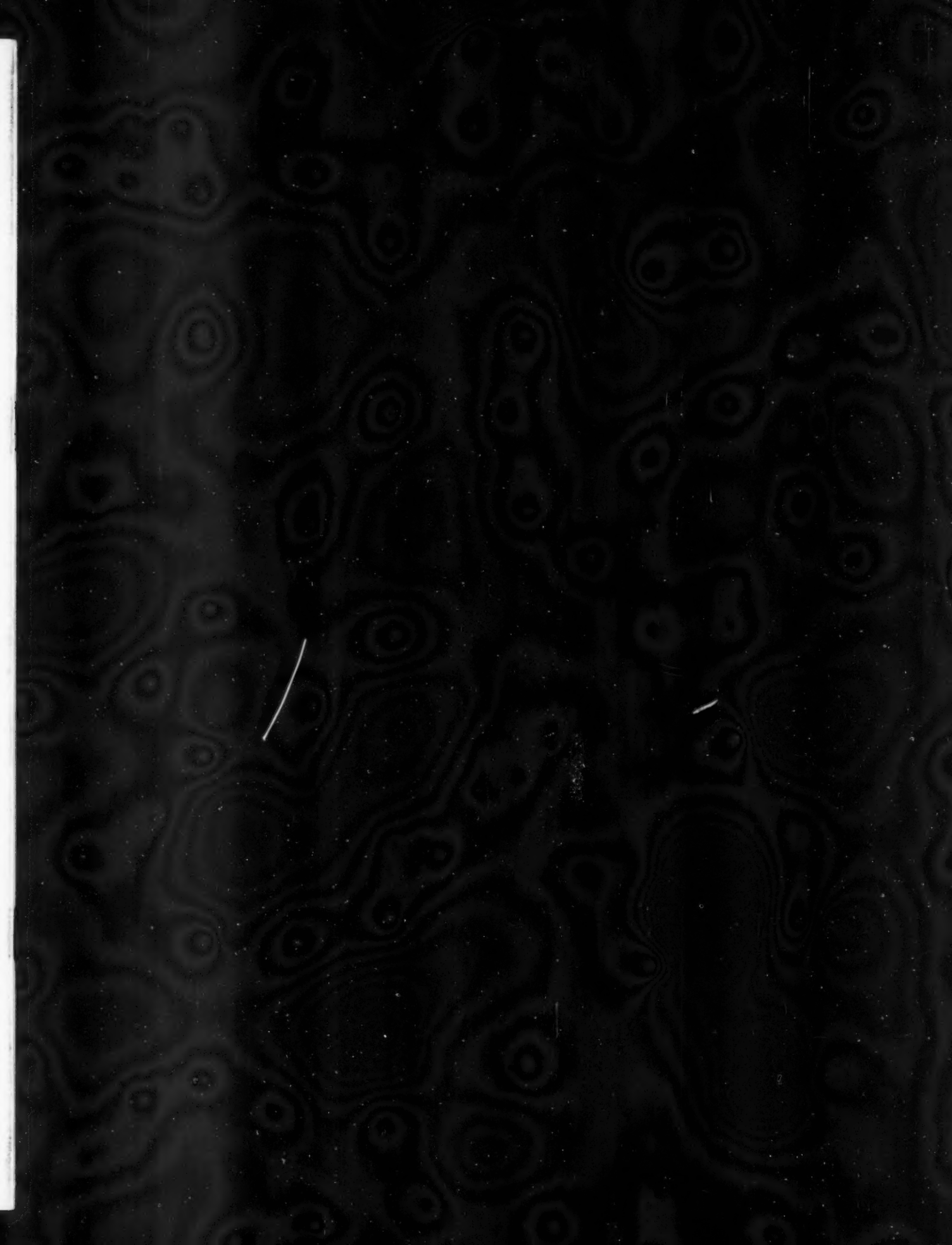
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